Advanced Combustion Technologies as an Alternative to Flue Gas Cleanup Systems for High Levels of NOx Reduction

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Summary

As a result of continued regulatory pressure, a number of older boilers are being retrofitted for continued operation at lower emissions. The use of cost-effective methods, which can be easily retrofitted to existing units, is becoming the key to determining the emissions compliance strategies for this equipment. When very high levels of NOx reduction are required, many times very costly flue gas cleanup systems seem like the only method of meeting the required levels. However, careful analysis of the system and the application of the several available combustion technologies can provide an alternate solution at a much lower cost.

Burning natural gas, and other fuel gases with no bound nitrogen, produces NOx through two main routes. The first is a thermal route where high flame temperatures cause nitrogen molecules from the combustion air to break apart and combine with oxygen to form NOx. As the name implies, thermal NOx formation can be reduced through control of peak flame temperature. The second route that produces NOx is the prompt mechanism. Under fuel-rich conditions, particularly when stoichiometry is under 0.6, both HCN and NH3 can be formed through the rapid reaction of CH with N2 to form HCN and N. Although prompt NOx is temperature-sensitive, the temperature sensitivity is not as great as with thermal NOx.

Since thermal NOx accounts for the majority of NOx formed firing gaseous fuels, typically anywhere from 80 to 95%, the majority of NOx control techniques have focused on this mechanism. The use of steam injection to reduce peak flame temperatures, and therefore reduce corresponding thermal NOx formation, has been employed for many years. The drawback to this technique is the economic impact, both in terms of the fuel costs to generate steam which is not available for process use and the impact on boiler efficiency.

It has been found that alternate methods of thermal NOx control, such as staged combustion and flue gas recirculation, could provide the required NOx reductions with a much lower operating cost impact. However, in cases where NOx reduction has to exceed 90% these techniques alone are not always adequate. The use of flue gas cleanup technologies, such as Selective Catalytic Reduction (SCR), has demonstrated the ability to achieve NOx reductions in excess of 90%. The drawbacks to these systems is the high capital cost of implementing them, particularly on existing units where space constraints exist, and their continued operational costs.

The reduction of NOx emissions on gas fired boilers through the use of a combination of combustion techniques, such as flue gas recirculation, fuel-air staging, and steam injection, provides a method to achieve these levels of NOx reductions without the cost and complexity of flue gas cleanup systems. NOx reductions of greater than 95% have been accomplished on several gas fired power boilers in a major refinery, and have been applied on a power boiler by a major utility as an alternative to Selective Catalytic Reduction (SCR). When used in conjunction with the other available NOx control techniques, the amount of steam injection required and its associated operating cost impact can be dramatically reduced. When compared with the cost of an SCR, or other flue gas treatment system for NOx control, both the capital and operating costs of these systems are dramatically lower.